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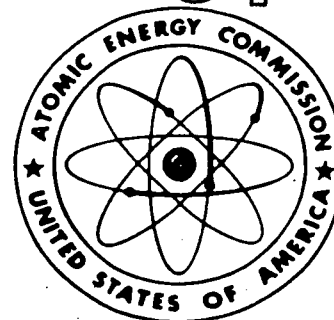
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EFFECTS EVALUATION

FOR

PROJECT RULISON



APRIL 1969

UNITED STATES ATOMIC ENERGY COMMISSION

NEVADA OPERATIONS OFFICE (AEC), Las Vegas

EFFECTS SAFETY DIVISION

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Effects Evaluation Division

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EFFECTS EVALUATION - PROJECT RULISON

April 1969

TABLE OF CONTENTS

EFFECTS EVALUATION - PROJECT RULISON

	<u>Page</u>
1.0 Introduction	1
2.0 Current Technical Event Data	3
3.0 Effects Predictions and Evaluations	3
3.1 Ground Motion	3
3.2 Structural Response	5
3.3 Ground Water Contamination	7
3.4 Containment	10
3.4 Table I - Summary of Phenomenology and Containment Predictions	10
3.5 Meteorology and Fallout	12
3.6 Environmental	13
3.7 Air Blast	16
3.8 Eye Burn	16
3.9 Close-In Effects	16
3.10 Aftershocks	17
3.11 Reservoir Structures	17
3.12 Mines and Gas Wells	20
4.0 Effects Programs	20
4.1 Seismic Instrumentation Program	20
4.1 Table II - ESSA/C&GS Seismic Instrumentation Plan .	21
4.2 Structural Response Program	22
4.3 Hydrologic Safety Program	23
4.4 Air Blast	24

Table of Contents (cont'd)

	<u>Page</u>
4.5 Bioenvironmental	24
4.6 Mines and Gas Wells	24
5.0 Effects Prediction Summary	24
Appendix A	29

<u>Figure Number</u>	<u>Page</u>
1. Index Map of Project Rulison Site	2
2. Predicted Peak Horizontal Acceleration versus Distance, Rulison Event, 40kt and 60kt Yields . .	4
3. Rulison Structure Summary	6
4. Water Wells and Springs in the Vicinity of the Rulison Project	9
5. Generalized Geologic Cross Section	11
6. Rulison Population Summary	14
7. Rulison Population Summary	15
8. Dams & Reservoirs in the Vicinity of Proj. Rulison .	19

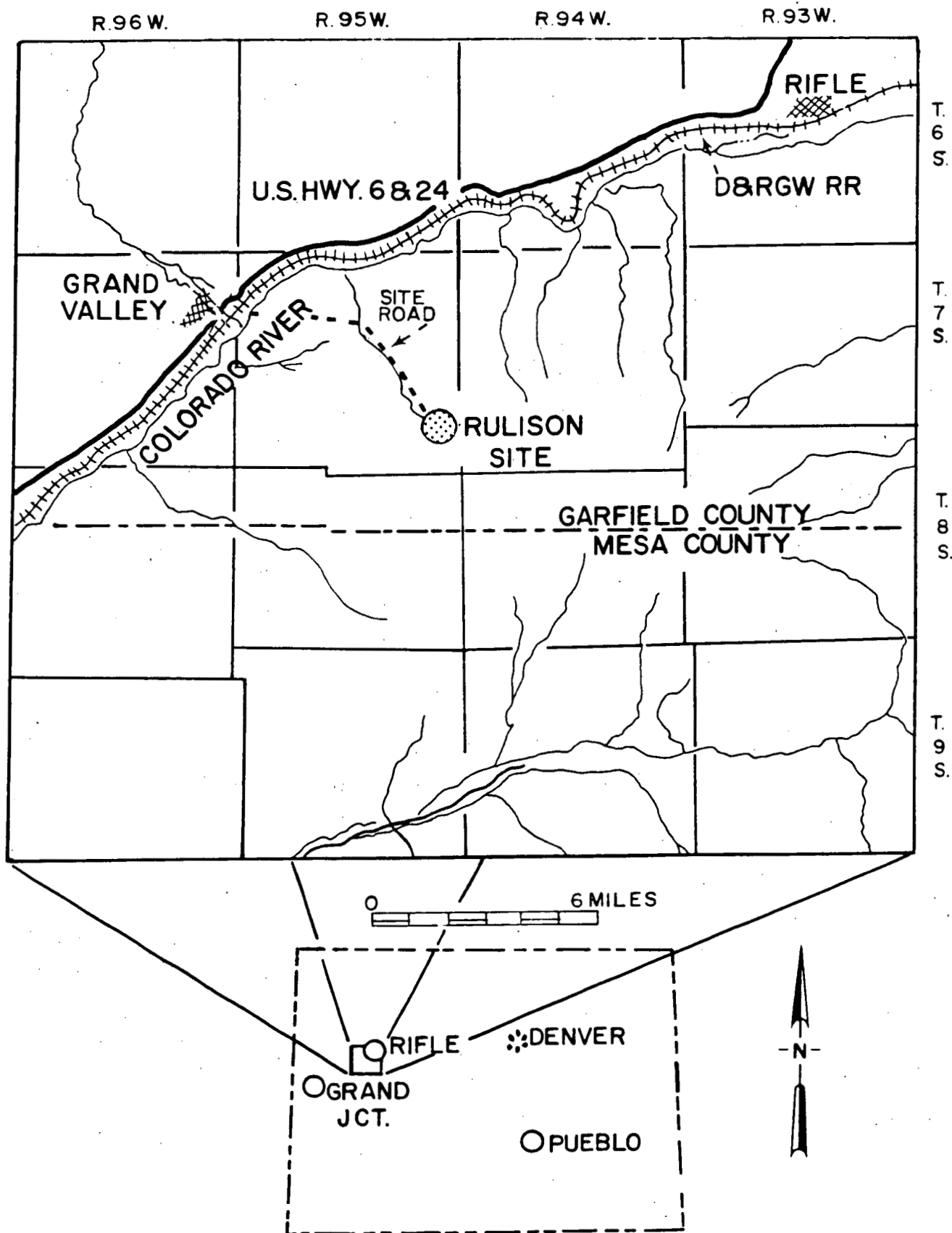
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EFFECTS EVALUATION - RULISON EVENT

1.0 INTRODUCTION

Project Rulison, located in Garfield County, Colorado, (Figure 1), is a joint industry-Government nuclear gas stimulation experiment in the Plowshare Program. The project, sponsored by Austral Oil Company, Inc. of Houston, Texas with CER Geonuclear Corporation of Las Vegas, Nevada as Program Manager, is defined in the Project Rulison Definition Plan^{1/} prepared by CER Geonuclear Corporation. The Effects Evaluation Report was prepared by Dr. R. Lee Aamodt of Los Alamos Scientific Laboratory and Mr. Richard A. Johnson of the Effects Evaluation Division NVOO, with predictions, appraisals and program descriptions contributed by Environmental Research Corporation, John A. Blume & Associates Research Division, U. S. Geological Survey, U. S. Bureau of Mines, Battelle Memorial Institute, ESSA/U. S. Coast and Geodetic Survey, ESSA/Air Resources Laboratory, U. S. Public Health Service, and Isotopes, A Teledyne Company.

The Rulison project is reviewed formally by three NVOO evaluation groups. The Test Evaluation Panel (TEP) reviews the containment aspects (release of radioactivity to the atmosphere) of the project and the Safety Panel of Consultants reviews the over-all environmental safety efforts exclusive of containment. The TEP evaluation is cited in paragraph 3.4. The Safety Panel of Consultants review is included as Appendix A. The Nuclear Safety Study Group performs



1.0 INTRODUCTION (cont'd)

a review of the assembly, transportation, emplacement and firing phases of the nuclear operation. Plans for the assembly and transportation of the Rulison explosive to the emplacement site have been reviewed and approved. Plans for emplacing and firing have been considered by the group and should be approved shortly. A site inspection will be made in late April.

2.0 CURRENT TECHNICAL EVENT DATA

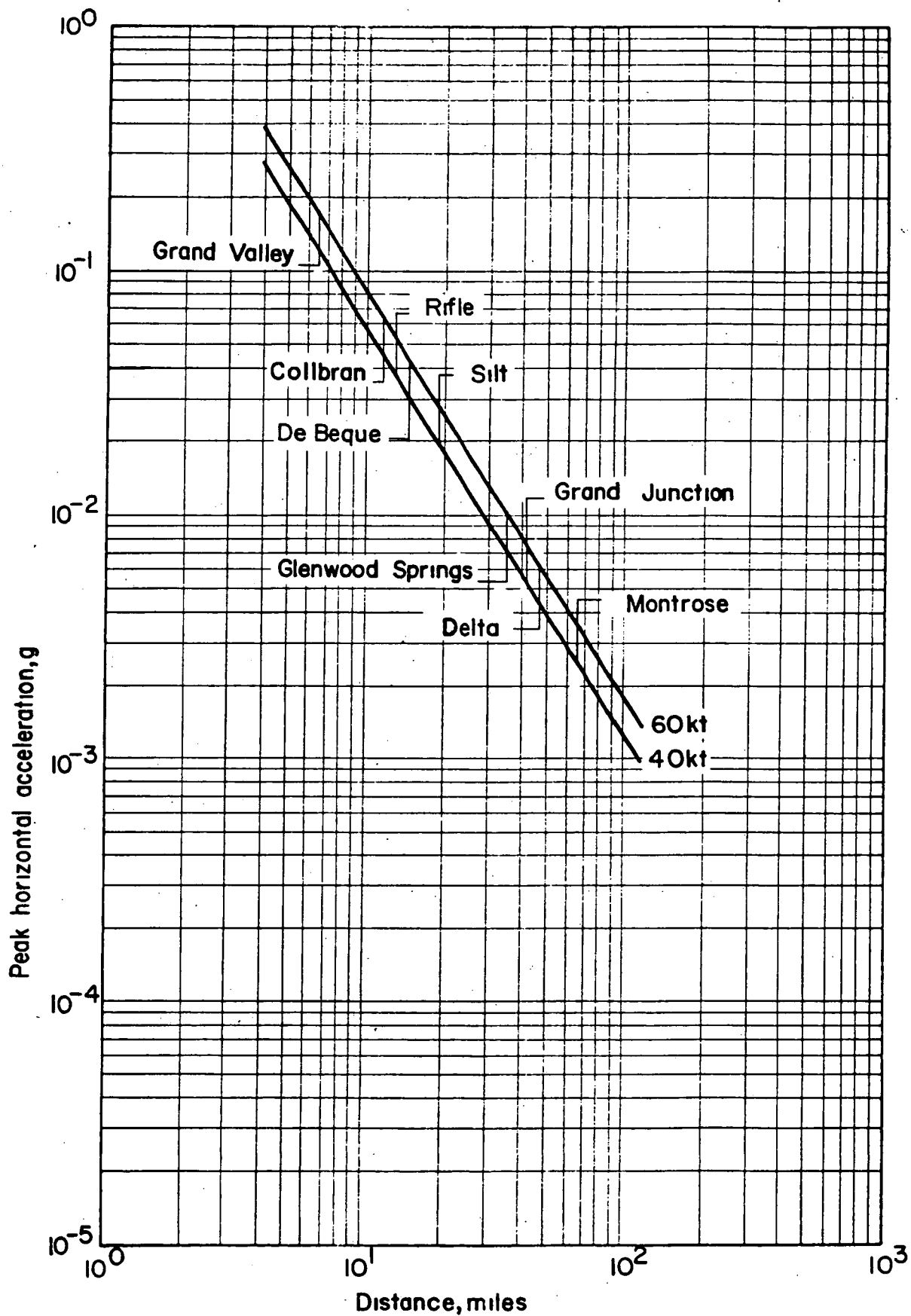
Readiness Date:	May 22, 1969
Yield: Design	40KT
Max. Cred.	60KT
Depth of Burial:	8430 feet
Scaled Depth of Burial:*	2,465 ft/kt ^{1/3} (design)
	2,151 ft/kt ^{1/3} (max. cred.)
Geologic Environment:	Mesaverde Shale/Sandstone

3.0 EFFECTS PREDICTIONS AND EVALUATIONS

3.1 Ground Motion

Predictions have been developed by the Environmental Research Corporation (ERC) for the Rulison design yield of 40KT and for

*Nevada Test Site (NTS) criteria for safety against release of radioactivity call for scaled depths of burial of 350 to 450 ft/kt^{1/3}. Rulison has a safety factor of 5 times this value.



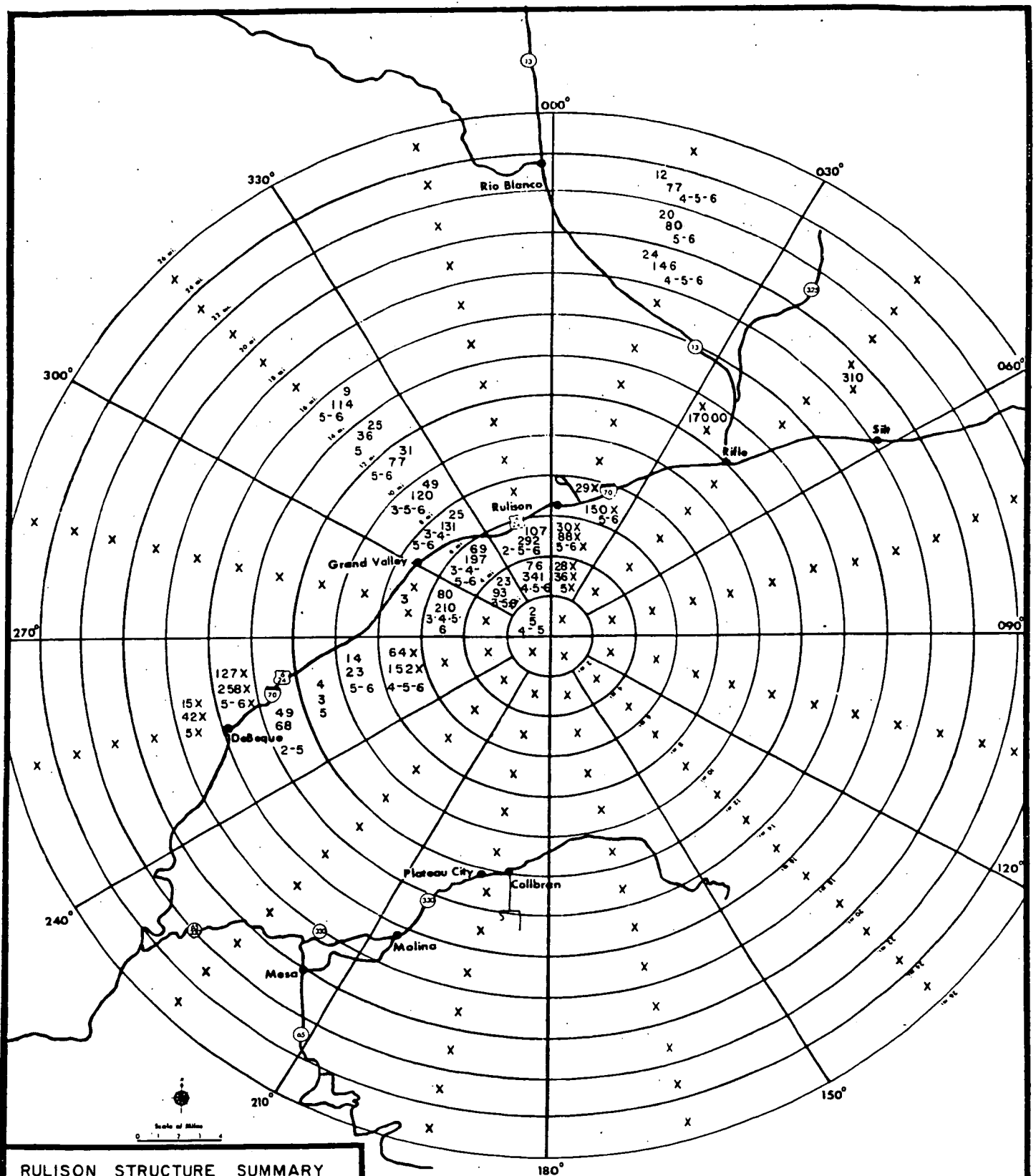
Predicted Peak Horizontal Acceleration versus Distance, Rulison Event, 40kt and 60kt Yields

3.1 Ground Motion (cont'd)

the maximum yield of 60KT^{2/}. The predictions are based on the assumption that ground motions from the Rulison detonation (Piceance Creek Basin) will be similar to those from the Gasbuggy detonation (San Juan Basin) because of the similarity of the geologic environments in which each explosive is emplaced. Data from the Gasbuggy stations located on hardrock and alluvium were grouped together as little or no amplification of motion was observed at alluvium stations. However, amplification of resultant ground motion at the Rulison stations located on thicker alluvium may occur as is the case with underground detonations at the NTS. Therefore, predictions of acceleration, velocity and displacement for locations with 200 feet or more of alluvium were made using a hardrock-alluvium amplification ratio developed on the basis of NTS experience. Predictions of peak horizontal accelerations at locations of interest are shown on Figure 2.

3.2 Structural Response

Based on the predictions of ground motions as described in Paragraph 3.1, John A. Blume & Associates Research Division (JAB) has prepared an inventory of structures within a radial distance of 15.0 miles from the detonation point (Figure 3) and have generally surveyed the structural population out to distances of about 60 miles.^{3/} Canyon and valley sections with slope areas or cliffs which may not be stable under the dynamic



RULISON STRUCTURE SUMMARY

000 NUMBER OF STRUCTURES
 000 VALUE, THOUSANDS OF DOLLARS
 0-0 TYPES OF STRUCTURES
 X NO INFORMATION AVAILABLE OR
 INVENTORY LIST INCOMPLETE

Taken from PROJECT RULISON: INVENTORY OF STRUCTURES by John A. Blume & Assoc.

3.2 Structural Response (cont'd)

action of the ground motion have been identified (Section 5.0).

The response of irrigation facilities, dams and reservoirs to the resulting ground motion has also been evaluated (Paragraph 3.11).

The Blume organization has begun preliminary work on a detailed condition survey of many of the structures in the vicinity of the shot, selecting the greater number near the detonation site and reducing the number to be evaluated as predicted ground motion from the detonation becomes less. Current predictions for the maximum yield are that the cost of bracing to minimize damage will be approximately \$9,000, that approximately 300 complaints of damage may be received as a result of the detonation and that the resulting payment of damage claims could amount to about \$130,000.^{4/}

3.3 Ground Water Contamination

To define the hydrologic regime for the detonation, the U. S. Geological Survey (USGS) participated in the hydrologic testing of the exploratory hole.

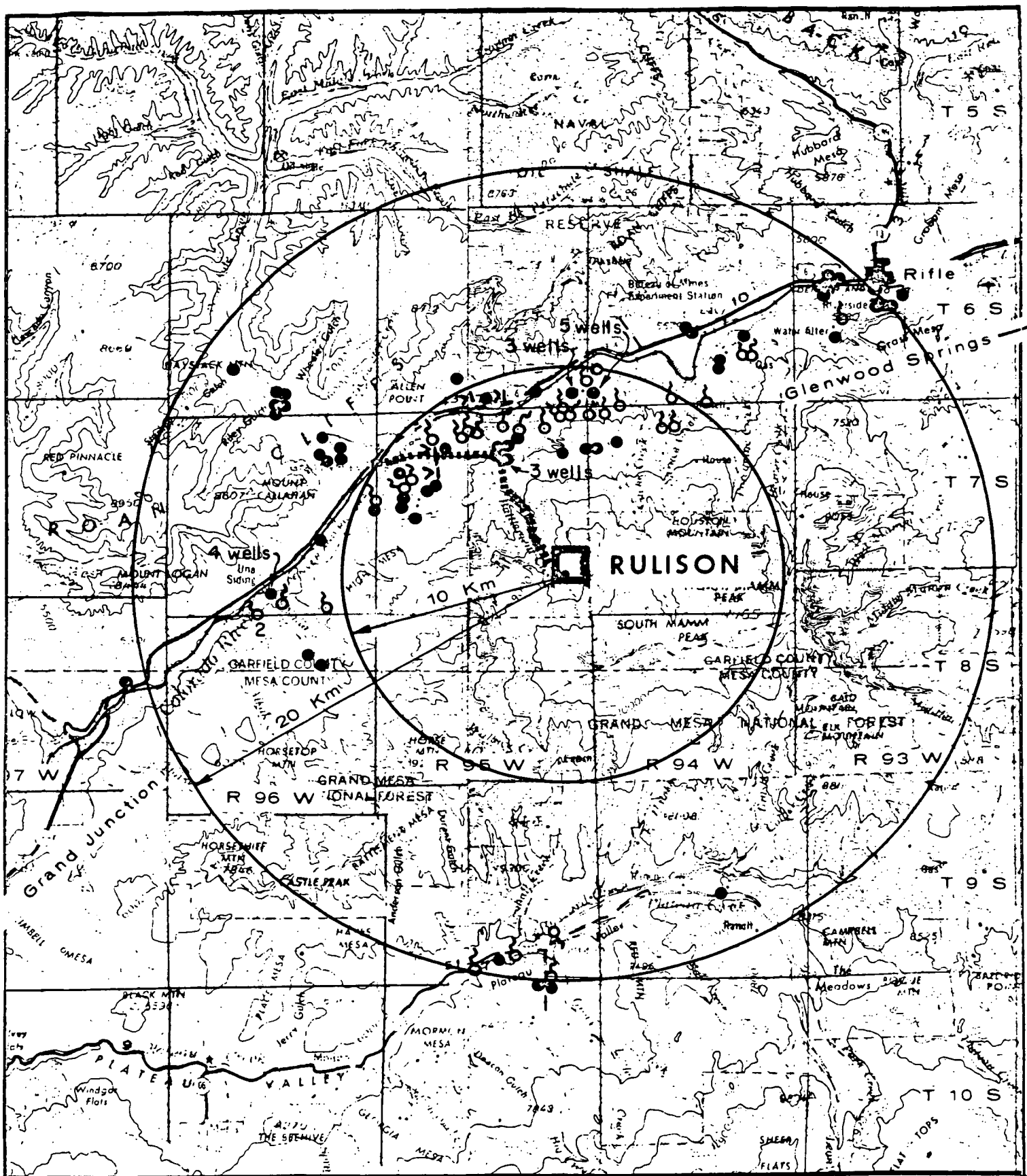
After installation of the casing hydrologic tests were performed by perforating and recementing the casing at depths below 6,000 feet from the surface. All zones that produced any water during

3.3 Ground Water Contamination (cont'd)

drilling or in which geophysical logs suggested the possibility of water were evaluated in this manner. Small amounts of liquid that were recovered were analyzed by the USGS and determined to arise mostly from the initial drilling and cementing operations. The USGS conclusion was that little or no mobile water occurs in the Ohio Creek Conglomerate and Mesaverde Group, which are the stratigraphic units most likely to yield water to the hole.^{5/}

The usual study of transport of radioactivity through underground water movement performed by Isotopes-A Teledyne Company could not be carried out because of lack of documentation of any flow. Their estimates, based on reasonable but conservative assumptions, were that the probability of transmission of greater than MPC levels of radioactivity in the underground water to any known use point is extremely remote.^{6/}

In the unlikely event of venting of gaseous debris, tritium could be introduced into the surface water. Therefore, springs and wells in the vicinity of the Rulison Site have been sampled by the USGS (Figure 4 depicts all wells and 90% of the springs located within 6 miles. After the snow melt the remaining springs will be located and sampled). Corresponding samples will be taken after the event.



WATER WELLS AND SPRINGS IN THE VICINITY OF THE RULISON PROJECT
U. S. GEOLOGICAL SURVEY INVENTORY MARCH 17-28, 1969

SCALE 1:250,000

- Well
- Spring
- >| Indicates more than one spring at location

3.3 Ground Water Contamination (cont'd)

Near surface water will be monitored as long as necessary after the event in a well drilled down hydraulic gradient from surface ground zero.

3.4 Containment

A geologic cross section of the emplacement hole is shown in Figure 5. Predictions of close-in physical effects of the detonation are tabulated in Table 1.^{2/}

TABLE 1

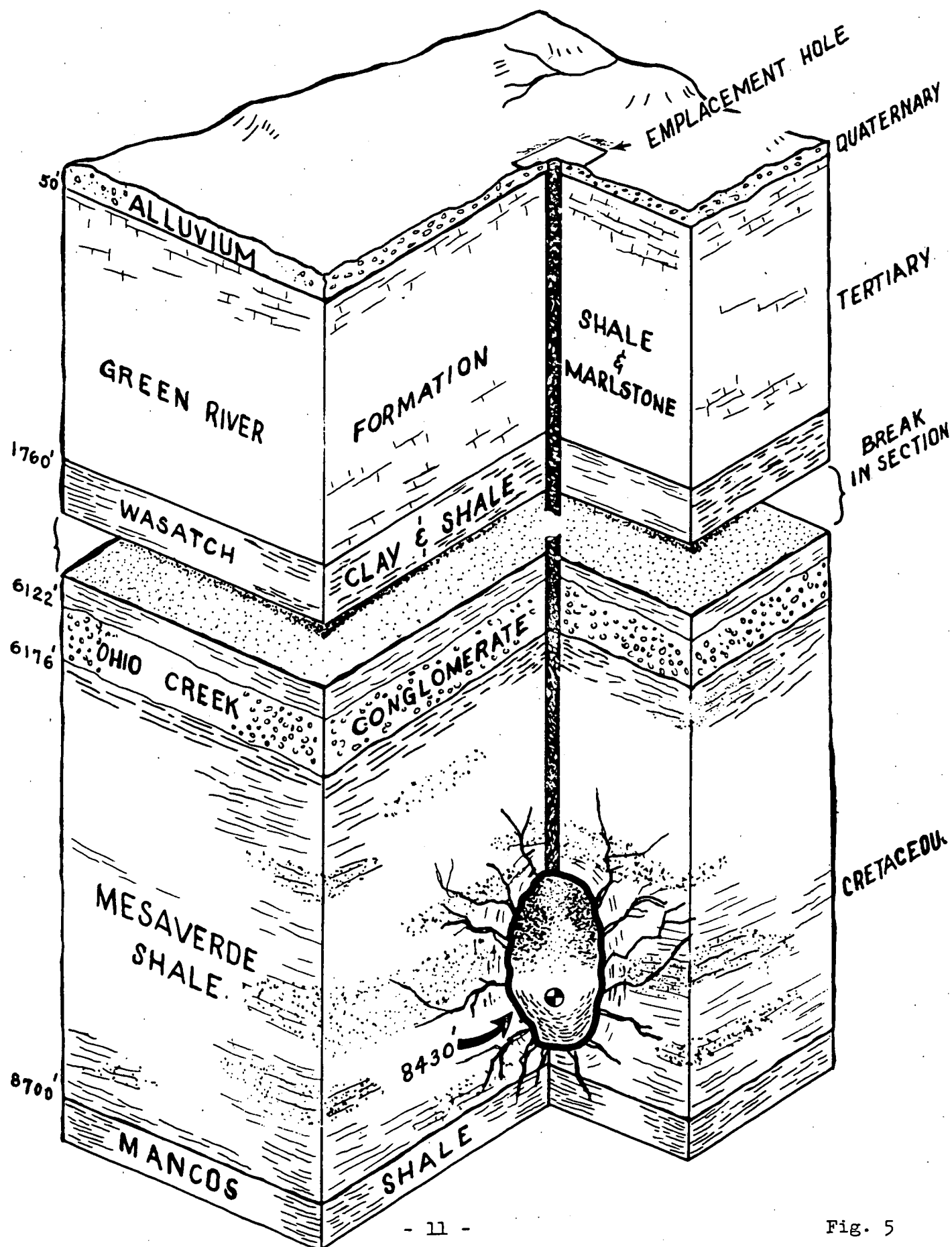
SUMMARY OF PHENOMENOLOGY AND
CONTAINMENT PREDICTIONS

<u>Prediction</u>	<u>Maximum Yield</u>	<u>Design Yield</u>
Cavity Radius	82-122 feet	72-108 feet
Cracking Radius	440-660 feet	390-580 feet
Maximum Radius of Gamma Radioactivity		
Above W.P.	160-280 feet	145-254 feet
Below W.P.	110-178 feet	100-161 feet
Chimney Height	340-510 feet	301-451 feet

The depth of burial for this device is five times that which has been utilized successfully at the NTS to contain underground nuclear detonations. The geologic structure in the vicinity of the detonation has been studied and no displacements or traces of faulting were found. Therefore, the probability of release of radioactivity to

PROJECT RULISON

GENERALIZED GEOLOGIC CROSS SECTION



3.4 Containment (cont'd)

the atmosphere by fissures is small. The Test Evaluation Panel (TEP) has reviewed the casing and cementing plan as well as the stemming concept.

On the basis of extensive NTS experience the Panel concluded that radioactivity would be contained, provided that the surface pipe closure was adequately engineered to survive the maximum predicted ground shock.

Detailed calculations showing the closure mechanisms ability to withstand the ground shock have been presented to the TEP for review. The Panel must be satisfied on this point before the detonation can proceed.

3.5 Meteorology and Fallout

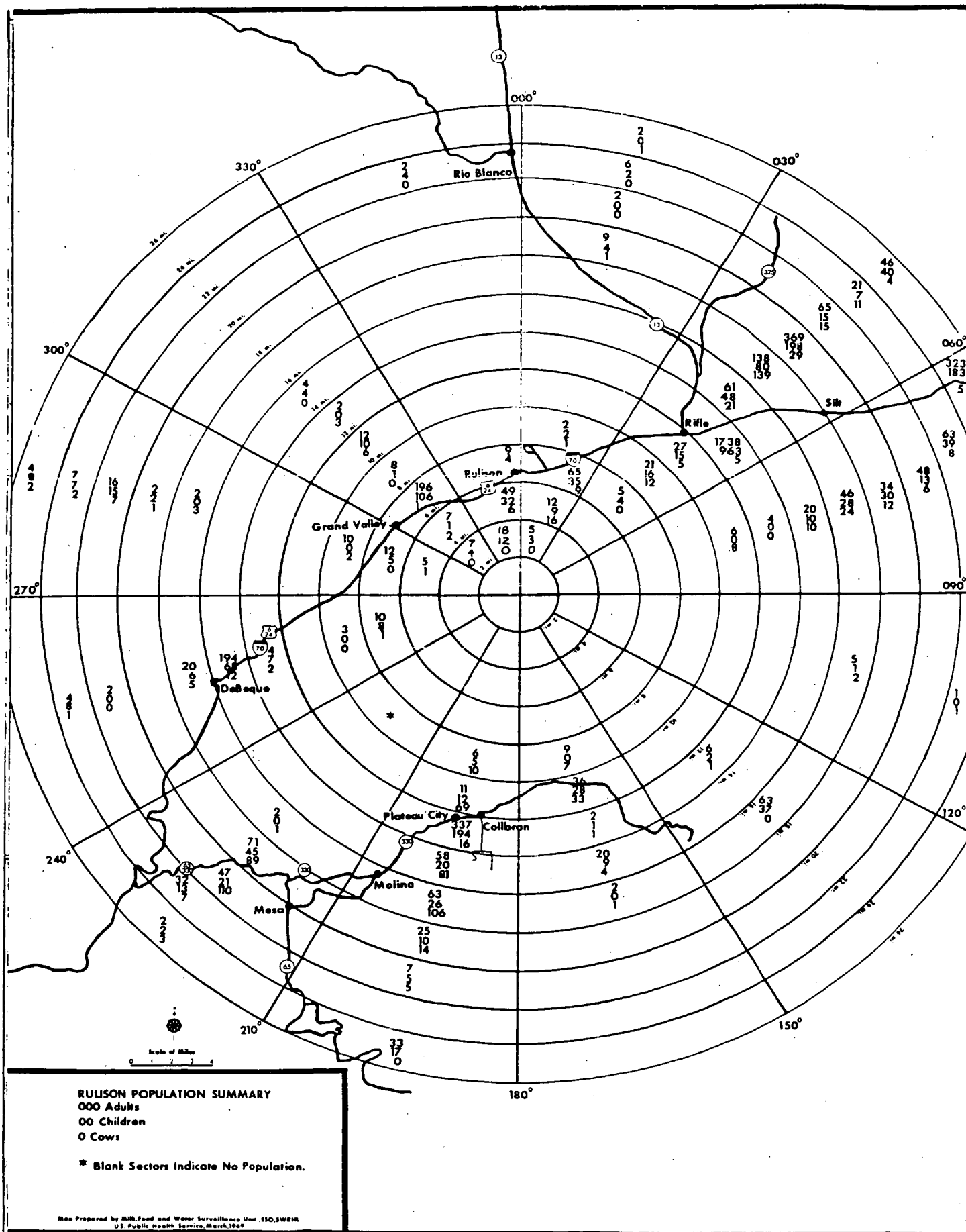
The fallout and climatological predictions show that various combinations of shot time meteorological conditions and firing sectors can be selected such that, should an unexpected venting occur, off-site population exposures can be held below the safety criteria established by AEC/HQ. Appropriate preparations to assure that exposures resulting from an unexpected radioactive effluent release will be explained in detail in the Test Manager's Operational Safety Plan.

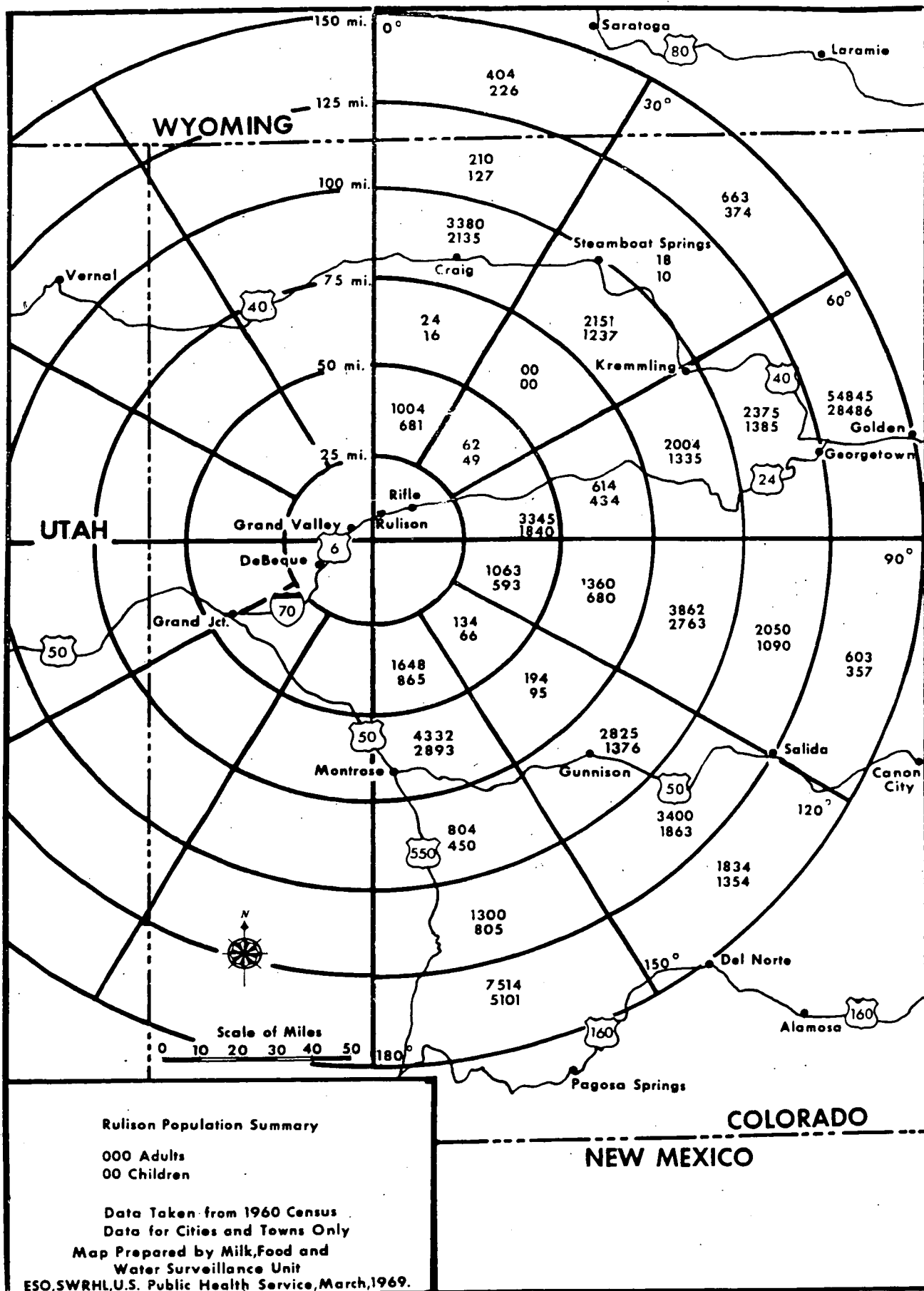
3.6 Environmental

The U. S. Public Health Service is responsible for maintaining a current census of human population and dairy cow and their distribution within a 25-mile radius of the detonation and to 150 miles in a down-wind sector. Summaries of this census are depicted in Figures 6 and 7.

An ecological survey of the area around the project site has been made to evaluate the seasonal wild game and range livestock populations and to identify any significant ecological consequences that might ensue from carrying out the project.^{7/} These populations except for the human census within 25 miles, are required only to plan courses of action in the unlikely event of accidental release of radionuclides.

During the drilling of Hole R-EX an incident occurred during which some fluid from the drilling operation spilled into Battlement Creek. To preclude any further possibility of this incident recurring as a result of the rupture of the mud pit dikes or splashing out as a result of ground motion, Austral Oil has made plans to clean the pits and adjacent slopes prior to the detonation. The effectiveness of this operation will be evaluated prior to the detonation to determine if further actions are deemed advisable to prevent the entrance of any contaminants into the Creek.





3.6 Environmental (cont'd)

Deleterious effects to wildlife as a result of ground motion have been investigated and none are foreseen.

3.7 Air Blast

Air blast predictions have been made by Sandia Laboratory. The prediction at surface ground zero is 0.05 psi overpressure. The threshold for damage to aircraft is 0.1 psi and therefore, no damage is foreseen. Damage to windows from air blast is not expected since overpressures are predicted to be well below the threshold at distances that windows are located.

3.8 Eye Burn

Eye burn predictions have not been prepared for the Rulison Event because the fire ball will be totally contained.

3.9 Close-In Effects

Providing all facilities are tied down and trailers blocked off their wheels and springs, damage to CP facilities should not be excessive. The possibility exists of blockage of Battlement Creek temporarily by earth slides. The effects of such partial blockage are predicted to be inconsequential and the resultant surge at the time of breaching to be substantially dissipated before reaching the populated area downstream. Spalling or surface fracturing has been evaluated and it is predicted that downward percolation of stream water will not occur nor will more than a

3.9 Close-In Effects (cont'd)

temporary, minor disturbance of the stream flow be observed. Measurement of the flow before and after the event will be made by USGS at a gauging station near surface ground zero.

3.10 Aftershocks

Aftershocks in the form of microtremors have been observed in connection with some underground nuclear events for the past several years. However, these aftershocks have been found to be at least two seismic magnitude units less than the nuclear explosion. Experience with the Gasbuggy Event in New Mexico, the Shoal Event in an earthquake active region of Nevada, and numerous events at the NTS at these low levels of yield indicate that aftershock phenomena are not measurable.

A literature search for Colorado earthquakes of magnitude greater than 3 during the time period 1638-1966 was performed by the USC&GS. Of the 300 earthquakes identified, none had epicenters within 50 miles of the Rulison Site. This lack of seismic activity further reduces the probability of detectable aftershocks from Rulison.^{8/}

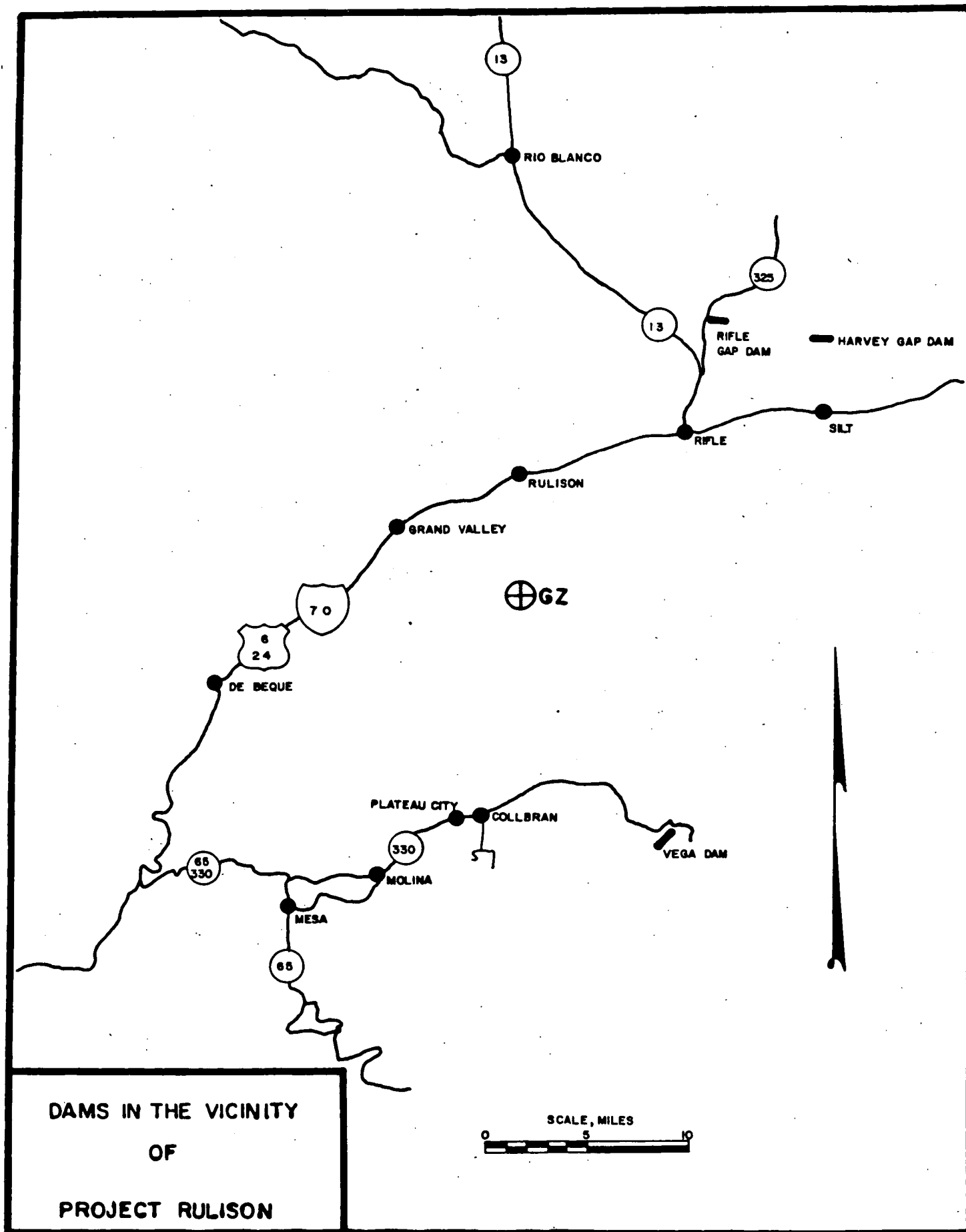
3.11 Reservoir Structures

A study of the generation of water waves (seiches) in lakes or reservoirs by ground motion and the effects of ground motion on dams has been made. With exception of several small earthfill dams at

3.11 Reservoir Structures (cont'd)

the Battlement Mesa reservoir, which require further evaluation, the study concluded that a hazard exists only at the Harvey Gap Dam. The results of the Harvey Gap Dam evaluation indicates that the factor of safety for the dam is approximately 1.0 with no seismic loading. Therefore, unless the elevation of the reservoir behind the dam is reduced to 40% of its spillway height, hazard to the downstream population could result.

The current evaluation has not been rigorous. Consequently, further contact with the Bureau of Reclamation is being made to determine if they have made a more rigorous analysis. Should revised statements be necessary after the contact an addendum to this report will be written. Evaluation of the Battlement Mesa reservoir dams will be completed after the snow melt allows a visual observation and inspection of the facilities. Seismic measurement of the response of Vega, Rifle Gap and Harvey Gap Dams will be taken in cooperation between the ESSA/Coast & Geodetic Survey (Harvey Gap), and the U. S. Corps of Engineers (Rifle Gap), and the U. S. Bureau of Reclamation (Vega). (Figure 8). The primary purpose of the cooperative instrumentation effort is for research into the response of dams.



3.12 Mines and Gas Wells

The general area around the site was surveyed for any active or inactive mineral industry developments that might be affected by the detonation.^{9/} Within the 10 mile radius from ground zero are the USBM and Mobile Oil Shale Mines. Out to 25 miles are the Union and Colony Oil Shale Mines, the Nu Gap and Harvey Gap coal mines and the Rifle Creek Vanadium Mine. The Mobile, USBM, Union and Colony Oil Shale Mines are research facilities that are not currently being operated. No hazard to the more distant mines is anticipated although some minor rock falls could occur at the close in oil shale mines.

The distance to the nearest gas well is 2.8 miles.^{10/} The nearest production well for the Gasbuggy Event experienced motions over 10 times that anticipated at this well from Rulison with no adverse effects.

4.0 EFFECTS PROGRAMS

4.1 Seismic Instrumentation Program

For the Rulison Event, the ESSA/C&GS Special Projects Party will field 30 seismic instruments. (Table II) These instruments will measure motions at populated localities and provide data for extrapolation of motions to be expected from any larger events in the same area. In addition, the Bureau of Reclamation

4.1 Seismic Instrumentation Program (cont'd)

and the Corps of Engineers will cooperate in obtaining measurements of the response of dams to the induced ground motion. The U. S. Bureau of Mines (USBM) will install instruments in a nearby oil shale mine to measure roof vibrations and deflections, pillar strain and microseismic noise rates that may be created by the Rulison ground motion. These measurements will enable the USBM to determine the response of the mine and evaluate whether this response is damaging.

TABLE II

ESSA/C&GS SEISMIC INSTRUMENTATION PLAN

<u>Station</u>	<u>Distance (miles) & Bearing</u>	<u>Station</u>	<u>Distance (miles) & Bearing</u>
Control Point	3 miles	Union Carbide Corp.	12.0 ₀ N 40° E
Eames Orchard	4.0 N 20° E	De Beque	12.6 S 70° W
Lemon Ranch	4.2 ₀ N 54° E	Collbran	13.1 S 5° W
Grand Valley	6.2 ₀ N 54° W	Tosco Mine	13.8 ₀ N 32° W
Ranch	6.7 S	Canyon	26.0 ₀ S 48° W
Rulison	6.0 N 9° E	Harvey Gap	20.0 ₀ N 50° E
Anvil Points	7.9 N 16° E	Mesa	19.2 ₀ S 31° W
Mobil Mine (entrance)	9.0 ₀ N 15° E	Silt	20.5 ₀ N 50° E
Rifle	12.2 N 45° E		

4.1 Seismic Instrumentation Program

TABLE II (cont'd)

New Castle	24.6 N 64° E	Delta	45.0 S 9° W
Cameo	25.8 S 49° W	Aspen	60.0 S 78° E
Glenwood Springs	34.0 N 71° E	Rangely	63.0 N 56° W
Cedaredge	36.4 S 04° E	Montrose	64.8 S 5° E
Grand Junction	40.0 S 54° W	Denver	154.0 N 81° E
Meeker	42.0 N 01° E	Salt Lake City	220.0 N 65° W
Paonia	38.0 S 27° E		

4.2 Structural Response Program

JAB will conduct "condition surveys" of sensitive structures from close-in areas to distant areas such as Grand Junction, Montrose and Aspen to document their condition before and after the Rulison Event and to determine if damage is caused by ground motion from the detonation. JAB will present a program for bracing structures (such as chimneys) to minimize damage, five weeks before the event. Some passive displacement gages may be installed on the structures chosen for detailed study. These passive gages will be monitored periodically pre-shot, immediately

4.2 Structural Response Program (cont'd)

prior to the detonation, and subsequent to the detonation to determine if any movement on existing cracks is due to the detonation itself or to natural phenomena.

4.3 Hydrologic Safety Program

The U. S. Geological Survey Water Resources Division has inventoried and sampled all water wells and 90% of the springs within 10km of the detonation point (See note paragraph 3.3) and will take measurements of the flow in Battlement Creek to determine the effect of the detonation on the ground and surface water supplies and flow. Several of the samples will be chemically and radiochemically analyzed pre- and post-detonation to determine if any change has resulted as a consequence of the detonation. The remaining samples will be analyzed only if a complaint is received post-event regarding the quality of the water at that location. Particular attention will be paid to water levels, flow measurements and structural conditions of existing wells and springs to be certain any post-event claims of damage can be adequately investigated. Evaluation of the event effects will be made to determine if any abnormal results would warrant revision of pre-event ground water contamination predictions or whether it is necessary to drill any post-detonation hydrologic monitoring wells.

4.4 Air Blast

No microbarograph program will be fielded on Rulison.

4.5 Bioenvironmental

Providing no significant release of radioactivity occurs post-detonation the only effort required will be to evaluate any possible damage to the ecological system caused directly or indirectly by the physical effects of the ground motion.

4.6 Mines and Gas Wells

Mine condition surveys conducted by the U. S. Bureau of Mines (USBM) will include the Rifle Creek, Nu Gap, Cameo and Mobile, USBM, Union and Colony Oil Shale Mines. In addition to the surveys, some instrumentation will be emplaced in the Mobil or USBM oil shale mine to measure the response of the mine to the induced ground motion.

The five gas wells (including R-EX) that exist within a five mile radius of the site will be examined and photographed in detail prior to the detonation. These wells, all owned or controlled by Austral Oil Company, Inc., will also be investigated and photographed after the event to document whether or not damage occurred.

5.0 EFFECTS PREDICTION SUMMARY

The Test Manager will define in the Operational Safety Plan any precautionary measures that will be instituted to minimize the

5.0 EFFECTS PREDICTION SUMMARY (cont'd)

possibility of injury to persons or damage to property, both on and off the Rulison Site. A summary of the hazards predictions that will be considered is as follows:

Peak horizontal ground motion predictions to a radius of 4.6 miles are in excess of .3g and therefore, a hazard could exist to all non-participating personnel in that area. Within that area, fragile hanging objects not removed to a safe location could be damaged and gas and electricity not disconnected could possibly cause a fire. In the town of Grand Valley, at the Anvil Point Research Station, and at various small ranches out to a radius of 8.7 miles, personnel not outside and away from structures to at least a distance of two building heights could be injured as a result of damage to seismically sensitive structures. At the Union Carbide Plant west of Rifle, personnel not instructed to remain clear of concrete block structures and tanks during the event could be injured as a result of minor damage to these seismically sensitive structures. Should the event be detonated on school days or when schools may be occupied in the towns of Rifle and Collbran, students outside, away from the buildings during the event would not be injured or would not be expected to panic. At residences in the nearby area, primarily those closer than 15 miles, the possibility exists that precariously balanced objects and bric-a-brac could fall if not removed or secured.

5.0 EFFECTS PREDICTION SUMMARY (cont'd)

A hazard could exist at the Cameo electrical generating plant should personnel be in high places or precarious positions at the time of the event.

Possible rock falls and landslides could occur on interstate Highway 70 and the Denver and Rio Grande Railroad in De Beque Canyon from a point just east of Palisades to the vicinity of Akin Siding. Portions of the highway from Rifle through Glenwood Springs also could be subject to rock fall hazards.

Rock falls could also occur on State Highway 75 at its junction with Interstate Highway 70 to the intersection of State Highway 330. An additional short stretch of Highway 330 in the vicinity of Molina may also experience rock falls. Portions of Highway 789 between Rifle and Rio Blanco paralleling the base of high cliffs of the Grand Hogback and canyon portions of the roads to Rifle Gap and Harvey Gap Dams and through Parachute Creek to the Tosco facility have precariously balanced rocks and rock falls occur at these locations from naturally occurring phenomena.

Within 50 miles, any person in a precarious position at shot time could become startled. The motion is not expected to be severe. However, if a person is in a precarious position at shot time, he could become

5.0 EFFECTS PREDICTION SUMMARY (cont'd)

startled and possibly lose his footing. Precarious positions might include ladders or scaffolding, standing on roofs or high walls, etc.

The motion that may be experienced at the closer locations would be of relatively high frequency and may be somewhat analogous to standing near a railroad track when a train passes. Farther from the detonation (probably at distances greater than 15 miles) the motion will impart more of a swaying sensation.

The following mines will be included in the pre- and post-shot safety inspection program. These mines, the remaining operating mines within 25 miles may wish to evacuate their facility if they are notified of the date, time of detonation, and any delays.

<u>Mine</u>	<u>Operator</u>	<u>Miles to GZ</u>
Rifle Ck (vanadium)	Union Carbide	22
Nu Gap (coal)	Henry & Louis Bendetti	20
USBM (oil shale)	Dept. of Interior	10
Mobile (oil shale)	Mobile Oil Co.	10
Union (oil shale)	Union Oil Co.	15
Colony (oil shale)	Cleveland-Cliffs Iron Co.	17
Cameo (coal)	Juanita Coal & Coke Co.	26

5.0 SEISMIC SAFETY RECOMMENDATIONS (cont'd)

As indicated in Section 3.11, it is possible that the Harvey Gap Dam could fail as a result of the minor additional loading of the dam by the seismic motion if the dam does not have the reservoir level reduced. Investigation is proceeding to determine the areas downstream that could be affected by the dam failure and resulting flooding.

References:

1. Project Rulison Definition Plan, CER Geonuclear Corp., Mar. 26, 1969.
2. Summary Report of Predictions, Rulison Event, NVO-1163-180, Environmental Research Corporation.
3. Inventory of Structures, Project Rulison, NVO-99-60, John A. Blume & Associates Research Division.
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5. Geology and Hydrology of the Project Rulison Hole, Garfield County, Colorado, USGS-474-16, April 4, 1969.
6. Radioactivity in the Hydrologic Environment, Project Rulison Final Report, April 11, 1969, Isotopes, A Teledyne Company.
7. Bioenvironmental Safety Considerations, Rulison Event, R. G. Fuller, Battelle Memorial Institute (Draft)
8. Earthquakes in Colorado, Memorandum, K. W. King, ESSA/C&GS to D. H. Edwards, NVOO, dated April 10, 1969.
9. Mineral Industry Development in the Vicinity of Project Rulison, Garfield County, Colorado, U. S. Bureau of Mines Memorandum Report February 28, 1969.
10. Proposed Gasfield Survey - Project Rulison, Memorandum Don C. Ward, U. S. Bureau of Mines, to Donald H. Edwards, NVOO, March 28, 1969.



UNITED STATES
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Mr. Robert E. Miller
Manager
Nevada Operations Office
U. S. Atomic Energy Commission
P. O. Box 14100
Las Vegas, Nevada 89114

April 11, 1969

Dear Mr. Miller:

The members of the NVOO Safety Panel of Consultants met on April 11, 1969 at Las Vegas. The Panel reviewed the ground motion and structural response predictions for Event Rulison and considered in some detail the safety aspects of the program for this event. This report contains the comments and recommendations of the Panel on this topic.

The Panel reviewed data presented to it on predicted ground motions from the detonation and the nature and possible extent of damage to structures at various distances, the possible damage to mines, the possibility of local rock slides, and the possibilities of failure of several dams in the general vicinity of the shot. The Panel also reviewed the precautionary measures proposed to accommodate the motions and damage potential. In general, the Panel feels that the predictions of motion are reasonable and conservative and that the estimates of damage to structures are in accord with previous experience and general scientific concepts.

The precautionary measures proposed appear adequate and we feel that damage or failure of structures close to ground zero have been evaluated and measures suggested that will avoid danger to personnel and domestic animals. The proposed control of traffic in areas vulnerable to rock falls, rock slides and slope failure will render minimal the dangers from such effects. Some damage may be expected in mines not currently in operation that are close to ground zero, but no special precautionary measures appear necessary there. For operating mines somewhat further away, the Panel recommends that personnel be evacuated to avoid exposure to falling rock and noxious gasses that might be released by such motions. It would be desirable to evacuate the mines out to a distance that includes the Dutch Creek Mine.

APPENDIX A

The Panel reviewed the data presented relative to ground water contamination and feels that the information presented by the USGS is in accord with practices and standards previously accepted by the Panel. In our opinion there is little probability that ground water contamination will be a problem. The Panel is in agreement with the proposed hydrologic safety and monitoring program described in the report "Effects Evaluation - Project Rulison", dated April 1969.

In general, therefore, in all respects save one, the Panel feels that the safety program for Rulison is acceptable and appropriate. However, we feel that we must make an exception to this statement in regard to safety of Harvey Gap Dam. Insufficient information has been made available regarding the properties of the materials of which the dam is constructed, the nature of the outlet works, and the present factors of safety of the dam with regard to failure even without ground motions related to a nuclear test. The Panel cannot accept without reservations a precautionary measure that would avoid damage by lowering the water level in the reservoir behind the dam before the event. It may not be possible to do this because of the volume of inflow that is presently occurring, and because of the limited size of the outlet channel. Moreover, the dam is believed to be composed of relatively impervious material and if this is the case would be subjected to large internal hydrostatic pressures following rapid draw-down. These pressures may reduce the safety of the dam to the extent that a relatively slight shock may result in its failure and consequent damage to downstream areas. There has been a failure of the original dam which was raised by construction of a new section. The new dam apparently has experienced approximately four feet of settlement since it was constructed. Moreover, there are evidences of piping near the spillway channel and perhaps at other points in the dam. Physical properties of the dam material have not been investigated nor have calculations been made of the stability of the dam under static or dynamic conditions. We strongly recommend that the determination of the properties and the necessary calculations be performed so that precautions can be taken to avoid failure of the dam. If this is not done, and assurance of the safety of the dam is not available it will be necessary to provide protection to downstream areas. Naturally this involves the acceptance of failure as one of the effects of the event. The conditions affecting the dam might be less severe in the fall when the reservoir level is low and the dam itself is not completely saturated.


Robert E. Miller

- 3 -


4/11/69

The Panel recommended in a letter of 27 February 1969 that Rifle Gap Dam, Vega Dam, and Harvey Gap Dam, be instrumented to obtain information about their response ground motions. The Panel recommends that where this instrumentation is provided, the properties of the materials be obtained in order to permit interpretation of the data.

Respectfully submitted,



Dr. Don U. Deere



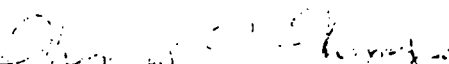
Dr. Lydik S. Jacobsen



Dr. George B. Maxey



Dr. Nathan M. Newmark



Mr. Thomas F. Thompson